REMARKS

Applicants appreciate the thorough examination of the application that is reflected in the Office Action dated September 6, 2006, and thank the Examiner for his time during the subsequent telephone interview of October 17, 2006. To expedite prosecution of this application, Applicants amend claims 1, 7, 10, 11, 17 and 18, and cancel claims 8, 9, 16, 19 and 20. After entry of the foregoing amendments, claims 1-7, 10-15 and 17-18 (15 total claims; 2 independent claims) remain pending in the application. Reconsideration of the application is respectfully requested in view of the above amendments and the following remarks.

Objection to Drawings

The drawings are objected to under 37 CFR 1.83(a) since they do not show every feature specified in the claims, in particular, the receiver of claim 10.

Applicants submit amended formal drawings herewith. Amended FIG. 3 now shows a receiver 309. Applicants also amend paragraph [0033] of the specification by adding the reference numeral 309.

Accordingly, in view of this amendment to FIG. 3, Applicants submit that this objection is moot.

Art-Based Rejections

Claims 1-7 and 10

Claims 1, 2-4, 8, 10 were rejected under 35 U.S.C. 102(e) as being anticipated by Numata et al., claims 5 and 6 were rejected under 35 U.S.C. 103(a) as being unpatentable over Numata et al., claim 7 was rejected under 35 U.S.C. 103(a) as being unpatentable over Numata et al. in view of White et al., and claim 9 was rejected under 35 U.S.C. 103(a) as being unpatentable over Numata et al. in view of Krisvoshlykov et al.

To expedite prosecution this application, Applicants amend claim 1 to include recitations previously appearing in claims 8 and 9. Claim 1 relates to a system for high speed data transmission. This system comprises:

> a light source for transmitting data as a first light signal;
>
> a lens having a focal length f for receiving said first light signal from said light source, said lens being approximately said focal length f from said exposed core of said large core multimode fiber optic cable,
>
> a large core multimode fiber optic cable, comprising:

> an exposed core having a core diameter, wherein a refractive index of said exposed core is substantially real to propagate said light signal with low loss, wherein a second light signal received from said lens at the exposed core is focused on and has a diameter approximately equal to said core diameter to reduce excitation of higher order modes; and
>
> a doped cladding layer around said exposed core of said large core multimode fiber optic cable that attenuates higher order modes generated in said large core multimode fiber optic cable to reduce pulse spreading effects that limit a length/data rate product, and
>
> wherein said refractive index of said doped cladding layer includes a complex component that attenuates higher order modes such that a third light signal output by said large core multimode fiber optic cable includes substantially only lower order modes. (Emphasis added.)

Overview

In an embodiment of the high speed optical data transmission system, an input light signal is launched to large core multimode fiber optic cable to excite low order modes. The consequence of launching the power in low order modes for multimode fiber optic cable 200 is that a short pulse will propagate for a long distance with only minimal pulse spreading since the higher order modes are significant contributors to the spreading because of the longer distance they travel. A further benefit in reducing pulse spreading in large core multimode fiber optic cable is achieved by modifying cladding layer to attenuate higher order modes. As described in the present application, for example, with reference to FIGS. 4 and 5, Applicants ran experiments to verify that the length/data rate product of a large core multimode fiber optic cable could be significantly enhanced by launching a light signal to propagate low order modes while attenuating the higher order modes that affect pulse spreading. As discussed in the present application, the test results demonstrate that both initial launching of only lower order mode light and active attenuation of higher order modes contribute to increasing the length/data rate product of a large core multimode fiber optic cable.

For instance, with respect to the exemplary implementation shown in FIG. 3 of the present application, lens 303 collimates and focuses light signal 302 to launch mostly lower order modes into large core multimode fiber optic cable 305. Light signal 302 is collimated by lens 303 and focused having a diameter substantially equal to the core diameter d of large core multimode fiber optic cable 305 when placed a distance f from core 306. The output from lens 303 is a collimated and focused light signal 304. Collimated and focused light signal 304 is injected into the core of large core multimode fiber optic cable 305 and excites a minimal

number of fiber modes, that is, modes with low values for l and m are produced. Hence, under these conditions the length/data rate product for large core multimode fiber optic cable 305 is maximized.

Applicants observed that the length/data rate product can be enhanced by selectively attenuating higher order modes without affecting the lower order modes. Large core multimode fiber optic cable 305 is modified to further attenuate the higher order modes thereby increasing the length/data rate product. In an embodiment of system 300, the modal discrimination of large core multimode fiber optic cable 305 is enhanced to damp the higher order modes that contribute to pulse spreading. In general, a length/data rate product of large core multimode fiber optic cable 305 is increased by incorporating absorption loss such that the refractive index of a cladding layer 307 is complex. An example of a methodology to incorporate absorption loss is to dope cladding layer 307 with an absorptive material. Cladding layer 307 is doped to produce a small absorption level that selectively attenuates only higher order modes. To explain further, the lower order modes large core multimode fiber 305 will propagate with very low loss if the index of the core layer n_1 is primarily real (has a very low absorption coefficient). Since very little of the low order modes exist in cladding layer 307, such modes will only be minimally impacted by the absorptive material. At the same time substantial amounts of high order modes exist in the cladding, and consequently undergo significant attenuations. The absorptive material to dope cladding layer 307 is selected to minimize attenuation of lower order modes while sharply attenuating higher order modes most responsible for pulse spreading effects that limit the length/data rate product of large core multimode fiber optic cable 305.

Numata et al.

Numata et al. relates to an optical transmission system S_a in which a lens 112 converges an optical signal OS_{in} outputted from a light emission element 111. The optical signal OS_{in} having passed through the lens 112 enters a multi-mode fiber (MMF) 12. A vertex Z_0 of the lens 112 and an input plane F_{in} of the MMF 12 are at a distance Z_1. The distance Z_1 is set to a value which is not equal to the distance from the vertex Z_0 to the focal point Z_{fp} of the lens 112. As a result, a low-cost optical transmission system can be provided in which the influence of mode dispersion is reduced.

Applicants respectfully traverse these rejections since Numata et al. fails to disclose that "a second light signal received from said lens at the exposed core is focused on and has a diameter approximately equal to said core diameter to reduce excitation of higher order modes," and that the "doped cladding layer includes a complex component that attenuates higher order modes such that a third light signal output by said large core multimode fiber optic cable includes substantially only lower order modes," as recited in claim 1.

In Numata et al., the cladding 122 was composed of a polymer such as methacrylic resin (PMMA). See paragraph [0040] of Numata et al. Moreover, as discussed at paragraph [0060], Numata et al. discusses that: "Thus, the present optical transmission system S_a allows the influence of mode dispersion in the MMF 12 to be reduced based on the adjustment of the position Z_1, whereby the transmission bandwidth of the MMF 12 can be broadened. This eliminates the need for a mode separator 84 (see **FIG.** 13) in the optical transmission system S_a, unlike in the conventional optical transmission system S_{cv}." Numata et al. attempts to reduce the influence of mode dispersion in the MMF 12 by adjusting the position of Z_1 which in turn reduces the NA_{in}.

Figures 2, 5, 7 and 8 of Numata et al. show that the light signal received from said lens at the exposed core is not focused on the MMF12 such that it has a diameter approximately equal to said core diameter to reduce excitation of higher order modes. Moreover, there is nothing in Numata et al. which indicates that the signal output from the MMF 12 includes substantially only lower order modes; nor that such reduction of lower order modes would result from the **combination** of providing a second light signal from said lens to the exposed core that "is focused on and has a diameter approximately equal to said core diameter to reduce excitation of higher order modes," and that the doped cladding layer includes a complex component that "attenuates higher order modes such that a third light signal output by said large core multimode fiber optic cable includes substantially only lower order modes," as recited in claim 1.

For at least the reasons discussed above, Applicants respectfully submit that Numata et al. fails to disclose that "a large core multimode fiber optic cable, comprising: an exposed core having a core diameter, wherein a refractive index of said exposed core is substantially real to propagate said light signal with low loss, wherein a second light signal received from said lens at the exposed core is focused on and has a diameter approximately equal to said core diameter

to reduce excitation of higher order modes; and a doped cladding layer around said exposed core of said large core multimode fiber optic cable that attenuates higher order modes generated in said large core multimode fiber optic cable to reduce pulse spreading effects that limit a length/data rate product, and wherein said refractive index of said doped cladding layer includes a complex component that attenuates higher order modes such that a third light signal output by said large core multimode fiber optic cable includes substantially only lower order modes," as required by claim 1.

Applicants submit that the other cited references, including Krisvoshlykov et al., fail to cure the deficiencies of Numata et al.

Consequently, the cited reference fails to teach or suggest at least these recitations of claim 1. Accordingly, the rejection of claim 1 should be withdrawn. Claims 2-7 and 10 also depend from claim 1, and describe additional novel elements and features that are not described in the cited references. Therefore, Applicant submits that these claims are separately patentable, and that the rejections of those claims should also be withdrawn.

<u>Claims 11-15, 17 and 18</u>

Claims 11-14, 16 and 19 were rejected under 35 U.S.C. 102(e) as being anticipated by Numata et al., claim 17 was rejected under 35 U.S.C. 103(a) as being unpatentable over Numata et al., and claims 15, 18 and 20 were rejected under 35 U.S.C. 103(a) as being unpatentable over Numata et al. in view of Siegman et al.

Claim 11 relates to a method for increasing a length/data rate product for a large core multimode fiber optic cable comprising a doped cladding layer around an exposed core of said large core multimode fiber optic cable, wherein the exposed core has a core diameter. Claim 11 recites the steps of:

> providing a data transmission comprising a sequence of light pulses;
> focusing said light pulses onto an exposed end of a core of the large core multimode fiber optic cable <u>such that a diameter of a light pulse is approximately equal to the core diameter to minimize excitation of higher order modes in the large core multimode fiber optic cable</u>; and
> using the <u>doped cladding layer to attenuate higher order modes of said light pulses</u> as said data transmission propagates down the large core multimode fiber optic cable to reduce pulse spreading effects that limit a length/data rate product <u>such that second light pulses output by said large core multimode fiber optic cable includes substantially only lower order modes</u>. (Emphasis added.)

For reasons similar to those discussed above with respect to claim 1, Applicants submit that Numata et al. fails to disclose at least the above-underlined recitations of claim 11. For instance, Applicants submit that Numata et al. fails to disclose that the doped cladding layer attenuates "higher order modes of said light pulses as said data transmission propagates down the large core multimode fiber optic cable to reduce pulse spreading effects that limit a length/data rate product such that second light pulses output by said large core multimode fiber optic cable includes substantially only lower order modes," as required by claim 11.

Accordingly, the rejection of claim 11 should be withdrawn. Claims 12-15, 17 and 18 also depend from claim 11, and also because those claims describe additional novel elements and features that are not described in the cited references. Therefore, Applicant submits that these claims are separately patentable, and that the rejections of those claims should also be withdrawn.

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In conclusion, for the reasons given above, all claims now presently in the application are believed allowable and such allowance is respectfully requested. Should the Examiner have any questions or wish to further discuss this application, Applicants request that the Examiner contact the undersigned attorney at (480) 385-5060.

If for some reason Applicants have not requested a sufficient extension and/or have not paid a sufficient fee for this response and/or for the extension necessary to prevent abandonment on this application, please consider this as a request for an extension for the required time period and/or authorization to charge Deposit Account No. 50-2091 for any fee which may be due.

Respectfully submitted,

INGRASSIA FISHER & LORENZ

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By: /ERIN P. MADILL/
Erin P. Madill
Reg. No. 46, 893
(480) 385-5060